

form and size were concerned, agreed perfectly with the parasites of *Anodonta*, but instead of the great number, had only six suckers on each side. Are these to be regarded as a distinct species? I think not. At any rate, we shall do better to regard this peculiarity as a case of atavism, especially as the two species are not widely distant. In any case the mite with five suckers on each side will have made its appearance earlier in the natural genealogical tree than that with from thirty to forty. But the form with six suckers is a reversion towards the primary form.

VIII.—*The Tertiary Shells of the Amazons Valley.* By HENRY WOODWARD, F.G.S., F.Z.S., of the British Museum.

OF the great river-systems with which explorers have made us acquainted, that of the Amazons is perhaps the most remarkable, as it is also one of the largest in the world. The courses of nearly all the large rivers of our earth lie in a north and south direction; the Amazons, on the contrary, runs nearly west and east. Situated almost beneath the equator, it traverses the southern continent of America from the eastern slopes of the Andes to the North-Atlantic Ocean (nearly fifty degrees)—a distance, computed by its course, of upwards of 4000 miles. Twenty great rivers, all of which are navigable, contribute their waters to its stream, which, under various names, drains considerably more than two millions of square miles of country. It is 40 miles wide where it enters the sea, whilst at 400 miles up stream, to which distance the tide ascends, it is still more than a mile in width*.

The stratified sandstones and clays observable in this great valley were attributed by Gardner to the Cretaceous series; Spix and Martius described them as belonging to the Quadersandstein formation† (Upper Cretaceous). By the earlier observers, according to Lyell‡, the stratified portions of this series were supposed to be of marine origin, and were successively referred to the Devonian, Triassic, and Tertiary epochs.

Our own countryman, Henry Walter Bates, who devoted eleven years to the exploration of the natural history of this region, has given us most graphic accounts, in 'the Naturalist on the Amazons,' of the scenery, physical features, &c., but does not dwell much upon its geology.

It was left to Prof. Agassiz, after his visit to Brazil (1865–

* Ansted's Physical Geography, 1867, p. 160.

† Hartt, 'Brazil,' p. 484.

‡ Principles, vol. i. p. 467.

1866), to give to the geological world a new reading of this great and wonderful region.

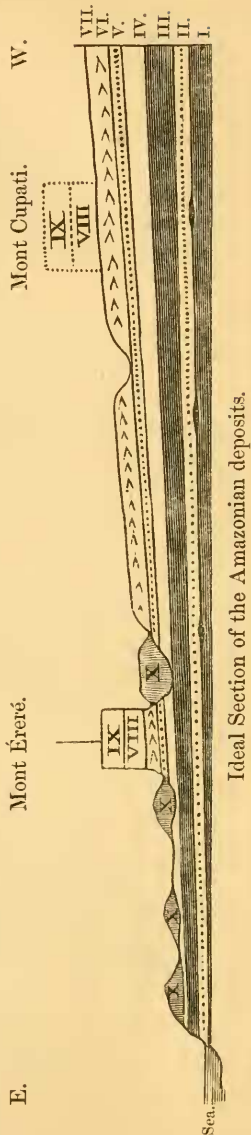
It would be impossible, in the length of an article such as the present, to enter fully into Prof. Agassiz's views; but it is essential to give a summary of them, in order to point out in what degree the writer differs from them.

In Prof. Hart's recently published work* on Brazil, a *résumé* is given of a paper by Prof. Agassiz and Dr. Coutinho† from which we extract the following description and section:—

“Prof. Agassiz thinks that the whole valley of the Amazons was formed at the end of the Cretaceous period, which has left traces of deposits in the province of Ceará and on the Upper Purús. Here and there, whether by denudations or by anterior dislocations, one sees more ancient rocks. Thus Major Coutinho has found palæozoic Brachiopods in a rock which forms the first cascade of the Tapajos; Carboniferous fossils have been collected on the banks of the rivers Guaporé and Mamoré, in Matto Grosso; and, finally, at Manáos, Coutinho has recognized slates or *phyllades* in a very inclined position, and beneath the formations of red sandstone of the Amazonian valley.

“Prof. Agassiz supposed that during the Tertiary period the Amazonian region was above water, and that the sandstones and clays that now fill it are drift.”

Annexed is a copy of the ideal section of these later deposits by Prof. Agassiz:—



Ideal Section of the Amazonian deposits.

* Scientific Results of a Journey in Brazil, by Louis Agassiz. Geology and Physical Geography of Brazil. By Ch. Fred. Hart. London, 1870. Trübner.

† Bulletin de la Société Géologique de France, 2^e série, t. xxv. p. 685.

Of this section the following explanation is given :—

“ I. Coarse sands (*sable grossier*), forming the base of the drift throughout, seen wherever the level of the water has uncovered the lower beds of plastic clays.

“ II. The mottled plastic clay (*argile plastique bigarrée*) shows itself on a large scale along the sea-coast at Pará, at the Island of Marajó, Maranhão, and here and there in the hollows along the course of the Amazons.

“ III. Laminated clay in very thin beds, with frequent indications of cleavage. This deposit appears to be more considerable in the banks along the course of the Rio Solimões than in the lower part of the Amazons. It is in these beds at Tonantins, on the Rio Solimões, that M. Agassiz has found leaves of dicotyledonous plants which appear to be identical with species at present living in the valley of the Amazons*.

“ IV. A crust of sandy clay, very hard, moulded in the inequalities of the laminated clay.

“ V., VI., VII., VIII., & IX. *Sandstone formation*,—sometimes regularly stratified and compact, especially in the lower beds (V.), such as one sees on the borders of the *igarapés*† of Manáos; sometimes cavernous and intermixed with irregular masses of clay (VI.), especially well developed at Villa Bella and at Manáos; at others all the characters of a torrential stratification (VII., VIII., & IX.). The deposits of this last nature are only seen in the elevated hills of Almeirim, Éreré, and Cupati, and in the most elevated cliffs of the borders of the river, as at Tonantins, Tabatinga, São Paulo, and on the borders of the Rio Negro.

“ X. The argilo-arenaceous unstratified drift, occupying all the inequalities of the soil resulting from the denudation of the sandstone with torrential stratification. It is in this drift that MM. Agassiz and Coutinho have found true erratic blocks of diorite, a metre in diameter, at Éreré. This formation is never met with on the cliffs elevated several hundreds of feet in height. There is not a trace of it on the summit of the hills of Éreré.”

“ The fact that the coarse sand No. I. appears throughout at the level of low water, that it follows the general slope of the valley, shows incontestably that the deposition of this

* “ These leaves occur in a fine, soft, grey clay, resembling very closely the recent alluvial clays of Brazilian rivers; they are excellently preserved. The leaf is partly carbonized; but it curls up from the surface on drying, and may be detached, leaving a beautiful impression of the venation &c. (Ch. F. Hartt.)”

Sir Charles Lyell (*Principles*, vol. i. p. 466) speaks of these leaves as being found in bed II., in the delta of the Amazons on the island of Marajó, whereas they really occur in Bed III., and more than 2200 miles up the Amazons.

† The Indian name for small streams; literally, “canoe-path,” from *igara*, a canoe, and *pés*, a path.

formation does not reach back to an epoch anterior to the excavation of the valley itself. The total thickness of the Amazonian drift does not exceed 300 metres (984 feet); it covers the whole basin of the Amazons, from the Andes of Peru and Bolivia to Cape São Roque; or, in other words, it is the most colossal drift formation known.

“Professor Agassiz believes that the Beds I., II., III. IV., or the coarse sands and clays, were deposited in a lake or sheet of fresh water occupying the valley of the Amazons, and sustaining on its surface a glacier descending eastward from the Andes, and furnished with a gigantic moraine in front stretching across the mouth of the valley and converting it into an inland freshwater lake. After the ice had broken up and become more or less disintegrated, and the waters of the lake had swollen, the sandstone formation V., VI., VII., VIII., IX. was laid down; then the barrier was burst; the waters of the lake, suddenly released, furrowed and wore down the sandstone beds, sweeping them entirely away over an immense area, leaving only isolated hills, like those of Éreré, Obydos, Cupatí, Almeyrim, &c., standing as remnants of the once universal sandstone sheet. After this period of turbulence and denudation came on an epoch of quiet, and in the bottom of the diminished lake the clays (No. X.) were deposited, while ice-rafts floating on its surface dropped here and there boulders to be buried in the accumulating material. Then the moraine was destroyed; the drainage of the waters furrowed deeply those clays, and even cut through them into the sandstone below, in which the various channels of the system of the Amazons are excavated. Professor Agassiz believes that the great barrier stretched across the Amazonian valley far eastward of its present extremity; and he has called attention to the similarity between the formations found spread over the coast of Maranhão and Piauhy and the Amazonian formations here described, showing conclusively that these deposits were once continuous. It is his belief that the Amazonian formation formerly extended a hundred leagues out to sea beyond the present mouth of the Amazons. There can be no doubt that there is a rapid waste of land now going on along the sea-shores of the mouth of the Amazons and of the coast eastward for a long distance, a waste amounting to even so much as two hundred yards in ten years in the Bay of Braganza—or a mile in twenty, as on the coast near Vigia, where an island a mile wide disappeared in that time. Since the Tertiary period,” says Professor Hartt, “at least, and, I believe, for the greater part since the drift, the whole Eastern Brazilian coast has suffered denudation by the sea to an im-

mense amount, and a very wide strip of Tertiary rocks has been removed. I believe that these deposits once extended beyond the Abrolhos, and that south of Cape Roque the sea has cut them away for a mean width of fifty miles or more."

Prof. Hartt adds:—"At first I was disposed to regard the Brazilian formation in question as Triassic; but I soon found that it was underlain unconformably by Cretaceous rocks in Bahia, and I came to the only conclusion possible—that it was older than the Drift, and newer than the Cretaceous. I can see no reason, therefore, for considering the coast beds any thing but Tertiary, though they may be, and probably are, very late Tertiary. It has seemed to me that the fact of the occurrence on an open sea-coast of clays and sandstones precisely similar to those occupying the lower plains of the Amazons, as at Pará, and in fact tying in with them, relieves one of the necessity of looking to a freshwater origin for the Amazonian beds."

These observations (coming as they do from one of Prof. Agassiz's own travelling companions and the geologist of the expedition, who has extended his knowledge of the geology of the district by a subsequent visit to Brazil) are of considerable importance. Whilst differing, however, from his chief as to the age and origin of these Amazonian beds, Prof. Hartt, like Agassiz, is a firm believer in the doctrine of "glaciers under the tropics down to the present level of the sea."

The only reason adduced by Prof. Agassiz for not regarding these formations as marine is the negative one, that he found no marine fossils in them. On the other hand, the only positive evidence which he seems to have found in proof of the freshwater origin of this vast deposit is the occurrence of dicotyledonous leaves in a single locality on the Rio Solimões, more than 2000 miles up the river.

The occurrence of erratic blocks of diorite "a metre in diameter" in the unstratified drift X. is adduced as indubitable proof of glacial agency; but the transporting-power of a river like the Amazons (several miles in breadth), swollen by rains and melted snows, may probably have sufficed. Or, as they occur elsewhere besides in the valley itself, they may quite as reasonably have been brought from the Antarctic by icebergs and dropped during the submergence of the eastern provinces.

On the 7th October, Prof. James Orton, of Vassar College, Poughkeepsie, New York, addressed a letter to the 'Geological Magazine' announcing that, in his late expedition across the continent, he had discovered a fossiliferous deposit at Pabos, and also that his correspondent Mr. Hauxwell, at his sugges-

tion, had explored in other places on the Amazons, and found fossils in abundance near Cochaquinas, on the south side of the Marañon. "The shells," writes Prof. Orton, "are all found in the coloured plastic clays*, which stretch unbroken from the foot of the Andes to the Atlantic." . . . He adds, "The forms are all very singular and unique; and from their extermination, especially of one genus (*Pachydon*) with all its representatives, we infer that the formation cannot be late Tertiary, and may be Miocene.

"The species indicate fresh- or brackish-water life; and the perfect preservation of the most delicate parts, some specimens retaining even the epidermis, shows a quiet lake or estuary. There certainly are no indications of a 'grinding glacier.'" "

Under date of Oct. 10, 1870, Prof. Conrad publishes, "in advance of the 'American Journal of Conchology,' descriptions of new fossil shells of the Upper Amazon," some of which had been previously described and figured in the fourth volume of the same journal by Mr. Gabb. Having since had the opportunity of examining many hundreds of these shells sent home by Mr. Hauxwell to Mr. Janson (Museum Street), I venture to append a few notes thereon.

[To be continued.]

MISCELLANEOUS.

Notes on Arctic Zoology. By Dr. ROBERT BROWN, M.A., F.R.G.S.
(In a letter to Dr. J. E. GRAY.)

4 Gladstone Terrace, Hope Park, Edinburgh,
November 23, 1870.

MY DEAR SIR,—I am at present working at the distribution of the North-west American faunas and floras, with a view to eventually producing a physical atlas of that region, and therefore venture to trouble you with this note to inquire if you have ever examined the skull of the *Phocæna* from Queen Charlotte's Islands, which the British Museum acquired from my collections; and if so, whether it is identical with any species of porpoise from the Atlantic. I remember that at the time (April 1868) you were inclined to believe that it was identical with *P. communis*. [I can see no difference in the skulls.—J. E. G.] If so, the fact would be rather interesting.

While I am at it, I may as well mention a few facts connected with arctic zoology, which you may find worthy of a notice in the 'Annals.' In a paper of mine on the arctic seals, in the 'Proceedings of the Zoological Society' for 1868, p. 425 (also translated in Petermann's 'Geographische Mittheilungen' for 1869), I discussed

* This is evidently Bed II. of Prof. Agassiz's section.